DOCUMENT RESUME

ED 406 350 SP 037 241

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TITLE The Effects on Student Learning of Transforming Professional Development Schools To Focus on National Content Standards.
PUB DATE 97
NOTE 31p.; Paper presented at the Annual Meeting of the American Association of Colleges for Teacher Education (49th, Phoenix, AZ, February 26-March 1, 1997).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS *Action Research; College School Cooperation; Elementary Education; Elementary School Mathematics; Higher Education; Matched Groups; *Mathematics Achievement; *Mathematics Instruction; *Problem Solving; *Professional Development Schools; Program Improvement; Standardized Tests; Tables (Data); Test Results; Urban Schools
IDENTIFIERS *Central Connecticut State University; *Hartford Public Schools CT; Reform Efforts

ABSTRACT

The School of Education and Professional Studies at Central Connecticut State University was funded to improve student achievement through school-based reform and to enhance the preparation of teachers who work in urban schools. The vehicle for enacting these goals was the creation of professional development schools near the university. One elementary school's first year (1995-96) implementation of its mathematics reform action research project is the focus of this study. The school is part of an urban school district with a 64 percent minority population. A matched pairs strategy was employed to allow for year-to-year control group comparisons and to provide for longitudinal follow-up. Teachers engaged in various types of professional development programs prior to the program. During the first year of implementation, students in grade four successfully learned the seven selected problem solving strategies. However, the Stanford Achievement Test results for grade four treatment students did not yield more positive results than for the matched pair control students, an outcome that can be explained in a variety of ways. It is concluded that professional development schools' action research projects should focus on interventions that have demonstrated prior success in student learning on standardized measures before the intervention is selected for adoption. Data tables are appended. (Contains 25 references.) (JLS)

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ED 406 350

The Effects on Student Learning of Transforming Professional Development Schools to Focus on National Content Standards

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Paper presented at the Annual Meeting of the American Association of Colleges of Teacher Education, Phoenix, AR, February 1997

Special thanks is extended to Central Connecticut State University student Sharon McKean for her assistance in analyzing the student holistic and standardized test data.

Running head: EFFECTS OF PROFESSIONAL DEVELOPMENT SCHOOLS ON STUDENT LEARNING

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Professional development schools have become part of the national effort to provide professional development for experienced teachers for purposes of enhancing student learning, to improve the education of novice teachers, and to conduct research on the teaching profession (Darling-Hammond, 1994; Holmes Group, 1990; Vail, Cooper, & Frankels, 1997). Initially, universities embarked on school-university collaboration with their own needs in mind--a systematic strategy for handling placements for field experiences and faculty-designed research (Berg & Murphy, 1992; Brown, 1992; Zimpher, 1990). Subsequently, restructured relationships emerged in school-university collaboration which were governed more by teacher and school interests (Lytle & Cochran-Smith, 1992; Zuelke & Nichols, 1996).

Today, hundreds of professional development schools operate to reform schools and improve the education of teachers through school-university partnering intended to be mutually beneficial. For schools, experienced teachers need to continue to grow and interact with peers and other educators to discuss ways to enhance educational experiences for students. Research needs to focus on whether these educational experiences actually improve student learning. For universities, prospective teachers need excellent models in their preservice training to become good teachers and university faculty need teacher perspective on school-based research.

Current literature on professional development schools has centered primarily on case descriptions of these developing models. Few studies have assessed the effects of practicing professional development schools (Teitel, 1996; Vail, Cooper, & Frankels, 1997). Although the expectations are high that children in professional development schools achieve at higher levels of learning only one study (Stallings, 1991) appears to have shown that improved student learning is an outcome of professional development school operation. Clearly there is an urgent need to conduct more research to determine if students learn better in these schools. Without data which supports the belief that students achieve higher learning, it will

be difficult for educational policies makers to advocate that professional development schools be widely replicated.

At the same time that professional development schools are being created new national and state academic content and student performance standards are being developed and implemented. One set of these national content standards, which are the focus of this study, are those developed by the National Council of Teachers of Mathematics (NCTM, 1989; 1991). These mathematics reform reports propose that the study of mathematics emphasize problem solving so that students can better understand mathematical content.

Thus far, some evidence exists that classrooms which have responded to these reforms have produced positive student achievement results based on single or partial year instructional intervention (Carpenter, Fennema, Peterson, Chiang, & Loef, 1989; Cobb, et al., 1991; Hiebert & Wearne, 1993). However, Wood and Sellers (1996) found that students needed to learn mathematics in reform-based classrooms for two years before significant differences in student achievement in mathematics could be observed. Moreover, in these studies, teachers transformed the entire mathematics program. It is not known what the results will be when teachers incrementally introduce these reforms--maintaining a textbook approach to teaching mathematics while simultaneously introducing problem solving strategies through a structured set of ancillary curriculum materials. Since this latter approach is likely to be an important step for the incremental introduction to new mathematics standards, it is important to understand if this approach provides significant changes in student learning.

The creation of professional development schools which focus on national content standards offer teachers and university faculty a useful opportunity to conduct collaborative action research to determine if these standards are truly producing the intended changes in student learning. Cochran-Smith & Lytle (1993) note that a strength of action research is that teachers often develop or select the materials and

assess the effects of their teaching on student progress, using multiple sources of data for analysis. Teachers who partner with university faculty in collaborative research have opportunities to field test new practices and reflect on the results of their work (Clark & Moss, 1996; Oja & Smuylan, 1989). Such data, including information on student achievement, can assist educators in determining the worth of adopted projects (Bickel & Hattrup, 1995). Furthermore, Slavin (1997) and Pogrow (1996) argue strongly that educators must assess the outcomes of school-based interventions in terms of student learning before recommending adoption by others. Similarly, Kimball, Swap, LaRosa, & Howick (1995), cited in Teitel (1995) caution professional development school representatives that

> the goal of improving students' learning experiences must take precedence over other aspects of partnership function, . . . [t]he means to effective partnership can easily become ends in themselves. For example, the energy for change in schools may become focused only on improving working condition for teachers, establishing more collaborative decision making structures, or creating more flexible schedules, all of which can be a means to an end of learning but cannot be ends in themselves. Administrative practice can change without passing advantage to the classroom. (p. 24).

What are effects on student learning of transforming professional development schools to focus on national content standards? In this study, a professional development school team identified the content area of mathematics as an area of student need. Using the content standards of the NCTM as the guide for its work, the professional development school team selected instructional materials designed to support their students in problem solving while at the same time a textbook approach to instruction continued. Teachers, in consultation with university faculty, increased the use of problem solving activities with students over a school year and measured the effects on student performance. The study, using a collaborative

action-research model, reports the results of the first year of focusing one professional development school on national content standards to improve student learning.

Method

The Professional Development School Network

In October of 1994, the School of Education and Professional Studies at Central Connecticut State University was funded by the Office of Educational Research and Improvement of the United States Department of Education to improve student achievement through school-based reform and to enhance the preparation of teachers who work in urban schools. The vehicle for enacting these primary goals was the creation of a set of professional development schools in the area adjacent to the university. Performance standards in the fields of mathematics and English/language arts provided the focus for school improvement projects. Professional teaching standards, developed by the National Board for Professional Teaching Standards and the National Council for the Accreditation for Teacher Education guided the effort to improve the preparation of teachers to teach in urban settings.

Ten elementary, middle, and high schools from the Hartford, Connecticut region formed a network of professional development schools to launch student standards-based action research school improvement projects and simultaneously guided the improvement of the university's teacher education program. The results of one elementary school's first year (1995-1996) implementation of its mathematics reform action research project is the focus of this study. Two fourth grade teachers and one third grade teacher systematically implemented an ancillary problem solving curriculum in their classrooms and completed data collection activities. Following this first year implementation, during the second year (1996-1997), the mathematics intervention became a schoolwide reform focus. Five additional teachers began full-year implementation and data collection

activities while the remaining teachers implemented the program at lower levels within their classrooms. The results of the second year of implementation will be reported in a separate article.

Sample and Design

The elementary school in this study is part of a school district with a 64% minority population. District elementary school enrollment includes 5000 children. At the district level 65% of the students live in homes with non-English as its primary language and 56% receive free or reduced-priced meals. The sample K-5 elementary school includes 480 students of which 54% represent minority populations. Of that number 43% are Hispanic and 11% African-American. In the sample school 54% of the students reside in homes with non-English being spoken and 42% receive free or reduced-priced meals. In this setting, one third grade and two fourth grade classroom teachers volunteered to participate in professional development and classroom implementation activities.

One dimension of the evaluation of the mathematics program intervention compared students at the sample school to matched students at a similar school in the district. The two schools were nearly identical in the percentage of students receiving free or reduced-priced meals and on mathematics achievement on the most recently administered Connecticut Mastery Test. Individual students were matched on the basis of standardized test scores routinely administered by the school district. Prior to the full year implementation, students in the sample third and fourth grade classroom who had taken the Spring 1995 Stanford Achievement Test in mathematics were matched with third and fourth grade students in the control school.

Implementation of the ancillary mathematics program began in the Fall of 1995 and continued through June 1996 school year. A matched pairs strategy was employed in order to allow for year-to-year control group comparisons and to provide a vehicle for longitudinal follow-up

of students who were identical in mathematics academic achievement before the program was introduced.

Mathematics Program Intervention

The problem solver activities for learning problem-solving strategies (Hoogeboom & Goodnow, 1987) was selected for the ancillary mathematics program intervention. Seven problem-solving strategies were taught and practiced by third and fourth grade students throughout the school year. The origin of providing systematic instruction and practice in problem solving in mathematics comes from the work of Polya (1973) and more recently has been promoted by the NCTM. The selection of these specific problem solving curriculum materials were based on positive comments from representatives in a nearby district which had used the program for several years.

The program is undergirded by a basic process of solving all problems including understanding the problem, devising a plan, carrying out the plan, and looking back. Additionally, seven categories of problems which students encounter in the study mathematics are directly taught and practiced. These include make an organized list, table, pattern, or picture; guess and check; work backwards; and logical reasoning. A total of 120 problems comprise these curriculum materials and permit teachers to develop various instructional implementation strategies during its full year of use.

Teacher Development

Spring 1995 Mathematics Workshops. Before beginning classroom implementation activities one university project facilitator provided three workshops to the sample school teachers. The content of these workshops included the NCTM standards, using hands-on mathematical manipulatives for teaching of fractions and measurement, and strategies for teaching problem solving.

Summer Institute. The sample teachers and the university faculty project facilitator, who had delivered the Spring 1995 mathematics workshops, completed a five day summer institute in 1995. At this institute the NCTM standards were shared and procedures for creating and carrying out an action research project were explained. At the conclusion of the summer institute the teachers and the university facilitator had developed a written plan for implementing and evaluating the use of new mathematics standards in classrooms focused on improving problem solving of third and fourth grade students.

Five additional site-based days during this summer were used by the institute team to further develop their implementation and evaluation plan. The seven problem solving strategies were discussed, the use of math manipulatives and cooperative learning was explored, a holistic scoring rubric was developed, and the concepts of using student interviews and mathematics journals were developed. The overall goal of these site-based days were to provide time for the teachers to make final preparations for the full-year of implementation and evaluation activities.

Study Group Meetings and Related Professional Development. In September 1995 a second university facilitator joined the project team. The first facilitator provided expertise in content and pedagogy in mathematics while the new university facilitator provided skills in research and the process of educational change. This five-person team met weekly to support full implementation of the action research plan and the data collection procedures. The team's weekly meetings included sharing classroom successes and concerns, providing additional training, coordinating the logistics of assuring that teachers had appropriate copies of curriculum materials, and implementing the testing and scoring procedures.

During this first year of implementation the team participated with schoolwide faculty in two professional development workshops related to implementing both the textbook and problem solving components

of the mathematics curriculum. They visited another professional development school network site to observe lessons and share problem solving strategies with teachers. They attended two professional development network forums which focused on sharing project strategies across school sites engaged in various action research interventions. The team sponsored a family math night for project classrooms, provided the minutes of its meetings to schoolwide faculty, and created suggestions for a scale-up model to involve the entire school faculty during the next school year.

Teacher Intervention Strategies

Multiple and flexible strategies were employed to infuse problem solving in mathematics in the curriculum using the selected intervention materials.

Grade 3. The Grade 3 teacher did the first 48 problems as a whole class activity. The key problem solving strategies were introduced in these first 48 problems with the title of each strategy labeled. She modeled the correct way to do each problem using transparencies. The teacher and the class circled the question, underlined the data, and looked for clues that would indicate what strategy to use. This teacher used these materials as a daily exercise for 20-45 minutes, five days a week. For problems 49-120, the appropriate strategy to employ was not named. During these problems the students worked independently as the teacher monitored the classroom activity, checked for understanding, and usually had one student do the solution on an overhead projector.

Grade 4 (A). This fourth grade teacher created a four-day cycle for project activities. On Day One the teacher modeled the strategy on the overhead projector and posted the transparencies on the blackboard for the students to refer to on Day Three. On Day Two the teacher again modeled the same strategy but used a different problem than used on Day One. This transparency solution was posted as well. Students helped in the modeled process because of the previous day's practice. On Day Three students independently completed a third problem requiring the same strategy and were able to refer to posted

transparencies. On Day Four students were given a fourth problem without being told which strategy to use. Students had to select from any strategy they had learned up to that point and solve the problem independently. This teacher created four half hour sessions of problem solving activities per week compeleting one four day cycle weekly.

Grade 4 (B). This fourth grade teacher developed a three-day cycle for purposes of project implementation. On Day One the teacher presented the new strategy to the whole class on an overhead projector. On this day a second problem using the same strategy was modeled on the overhead projector while the class contributed to the solution. On Day Two, working in pairs, students completed a same strategy problem as had been modeled on Day One. A problem using this same strategy was assigned for homework. On Day Three, the homework problem was reviewed in a full class format. This teacher replaced one textbook-based mathematics period per week for purposes of implementing the intervention problem solving activities.

Assessment Instruments

Holistic and standardized assessment instruments were used to determine the overall effects of focusing this professional development school on improving student learning in mathematics. A pre- and post-test was administered to treatment classrooms in October 1995 and May 1996. This test consisted of seven problems matched to the seven problem solving strategies embedded in the ancillary curriculum materials. Additionally, after teaching a problem solving strategy students were administered a whole class selected problem test to determine their level of learning. A holistic scoring rubric, comprising a scale of one to four, was used to score each pre-post and selected problem test.

Additionally, randomly selected high, medium, and low achievement students were interviewed and asked to mark a four-point Likert-scale instrument indicating their perceived competence in a problem solving approach to mathematics. The scale ranged from "I do not understand how to solve problems. I do not know where to begin. I am

usually stuck," to "I understand how to solve problems. I can clearly explain my answer. I always have acceptable answers."

Two sets of standardized measures were utilized. The first was the Stanford Achievement Test (SAT)--sub-test Mathematical Applications. Both treatment and control students were administered this test in May 1995 and again in May 1996. The second was the Connecticut Mastery Test (CMT)--Mathematics Section--administered to students in Connecticut beginning in the fourth grade. Students in the treatment and control third grade classrooms completed this test as they entered fourth grade in September 1996. Students in the fourth grade treatment classrooms completed the CMT in September 1995 as fourth graders and then as they entered fifth grade in September 1996.

Analyses

The first year problem solving holistically scored data were analyzed in several ways. T-tests were utilized comparing pre-post problem solving test data for Grade 4 classrooms (Grade 3 whole class data was not available). For Grade 4, means were computed for selected problem tests administered after teaching each strategy.

A stratified random sample of at least one student in the categories of high, medium, and low achievement was selected in each of the three classrooms. These students' pre-post problem solving mean test data, and Likert-scale perceived competence in a problem solving approach to mathematics were compared. Since sample size was small no statistical tests were performed.

For the SAT instrument, 1995 to 1996 raw score ANOVAs compared treatment and control students. Using ANOVA procedures, the CMT Grade 3 1996 treatment and control students' raw score results were compared. For Grade 4, t-tests were employed to compare their results on the 1995 and 1996 CMT. Since the number of items for the second year of this test increased, the proportion correct on each test

sub-scale were used for data analysis purposes. Finally, for both Grade 3 and 4 CMT tests, seven objectives were selected in the area of Problem Solving/Applications and appropriate t-tests and ANOVAs using raw scores were conducted.

Results

Holistic and Likert-Scale Measures

Whole Class--Grade 4. Table 1 reports comparisons of Fall to Spring holistic test scores for both Grade 4 students. These yielded significant positive results for all seven strategies. Teachers taught these strategies well, and as measured by pre-post tests highly related to the actual problem solving strategies, students learned these at significant levels in both classrooms.

Insert Table 1 about here

For selected problem tests (Table 2), administered after teaching each of five of the program's strategies, for the most part, students scored 3 or better on these selected problem strategies. Students were demonstrating good understanding of these problem solving strategies at the conclusion of their introduction and practice.

Insert Table 2 about here

High, Medium, & Low Achievement Students. When high, medium, and low achieving students were compared on their understanding of the seven strategies (Table 3) all categories of students made pre-post-test gains of 1.5 or better. The lowest achieving students made the greatest gains.

Insert Table 3 about here

However, as Table 4 shows, on selected problem tests administered after teaching the program's strategies, there were differences for

high, medium, and low achievement students as well as differences based on the kind of strategy tested. Overall, the lows scored lower than the highs and mediums and the strategy of working backwards was the most difficult for all three groups.

Insert Table 4 about here

Comparisons of the Likert-scale perceived competence in a problem solving approach to mathematics (Table 5) yielded strong scores from the highs and mediums and lower scores from the lows. Although the lows made gains in understanding these seven strategies that exceeded the highs and mediums (see Table 3), they still perceived their problem solving competence lower than the other groups of students.

Insert Table 5 about here

Standardized Measures

Stanford Achievement Test. In comparing treatment to control group students on the Stanford Achievement Test (Table 6) the Grade 3 treatment students significantly outperformed their matched pairs. There were no differences for either classroom of the Grade 4 students.

Insert Table 6 about here

Connecticut Mastery Test. The CMT analyses for Grade 3 (Table 7) indicates no differences on this measure. There were no significant differences between Grade 3 treatment and control students on the total test nor the four sub-tests analyzed.

Insert Table 7 about here

When the results of the seven objectives from the sub-test of Problem Solving (Table 8) were analyzed for Grade 3 there were no significant differences between treatment and control students.

Insert Table 8 about here

The Grade 4 CMT produced significant results in four of the five areas of comparison (Table 9). In the areas of number facts/computation, measurement/geometry, and the total test score both Grade 4 students scored significantly lower when comparing 1995 and 1996 results. In the sub-test area of concepts Grade 4 (A) scored significantly lower when comparing 1995 and 1996 results. In the sub-test area of problem solving there were no significant differences.

Insert Table 9 about here

When the results of the seven objectives from the sub-test of Problem Solving (Table 10) were analyzed for Grade 4 students, except for one objective, there were no significant differences. However, in the objective, "write story problems from number sentences," students from both Grade 4 classrooms scored significantly lower when comparing 1995 and 1996 results.

Insert Table 10 about here

Discussion

During the first year of the implementation of this problem solving mathematics project evidence shows that students in Grade 4 successfully learned the seven selected strategies. When considering overall gains in all classrooms the high, medium, and low achievement students made gains in their use of these strategies. It even appears that the lows made the greatest gains. Grade 3 treatment students

significantly outperformed their control matched pairs on the SAT standardized measure.

However, on all specific selected problem solving strategies, the lows scored lower than the highs and mediums and the strategy of working backwards was the most difficult for all groups of students. In spite of making overall positive gains in all the strategies, the lows perceived their problem solving competence lower than the other groups of students. Additionally, the SAT results for Grade 4 treatment students did not yield more positive results when compared with their matched pair control students. Moreover, the Grade 4 CMT data seems to indicate that students fell behind their previous levels of achievement as measured by this indicator.

How can these results be explained? That students learned these seven strategies of problem solving is a testament to the good teaching they received throughout the school year. Each of the teachers developed an appropriate methodology for implementing this ancillary problem solving curriculum. They were able to teach successfully all achievement level students. The Grade 3 teacher appears to have been the highest implementer of the program while maintaining the highest level of implementation of the textbook-based curriculum. On a daily basis, she taught and practiced these problem solving strategies and perhaps the overall time students were engaged with these categories of problems enabled her students to significantly outperform the matched pair control students on the standardized SAT measure.

The fact that the lows perceived their problem solving competence lower than the other groups of students may be attributable to the need for teachers to provide more positive reinforcement for students who are identified as low ability. It is clear that the lows can make comparable gains in their understanding of these strategies. With continued regular positive praise for gaining understanding, the lows may begin to perceive that they are competent in solving mathematical problems.

The somewhat disappointing results on the standardized measures for Grade 4 perhaps can be explained in a variety of ways. The amount of time devoted to teaching and practicing the problem solving strategies, while at the same time maintaining high levels of implementation of the textbook-based curriculum may not have been adequate at least to attain positive results on the SAT measure. Additionally, as Wood & Sellers (1996) discovered, it may take at least two years in mathematics reformed classrooms for significant results to emerge on standardized measures. Perhaps the high SAT pretest scores created a ceiling effect that thwarted anticipated differences between treatment and control students.

For the Grade 4 CMT measure, students taking this high stakes test in Connecticut are provided extensive practice prior to the test administration. Grade 4 students participate in daily practice, homework assignments, and after-school tutoring prior to taking this test. In Grade 5, since the test is not widely administered, no practice opportunities are provided. Perhaps a practice effect skewed the 1995 Grade 4 data. Perhaps a ceiling effect may have also influenced the Grade 4 CMT comparisons.

There also appears to be little theoretical evidence that students who learn these strategies well will translate the results on more traditional standardized measures of mathematical achievement. Although the teachers in this study maintained their use of the textbook curriculum in a variety of ways, they did not emphasize the more routine problems encountered on standardized tests and this may have been associated with less impressive results on the standardized measures. If the NCTM Standards, particularly in problem solving, are to become widely accepted and translated into curriculum and instructional materials, it will be important for high stakes standardized measures of achievement to be in close congruence with these problem solving strategies.

Finally, it may be essential for action research projects associated with professional development schools to select interventions which have demonstrated prior success in student learning on standardized measures before the intervention is selected for adoption. Much time and effort is devoted to planning, implementing, and evaluating an intervention described in this study. It would be prudent to not adopt curriculum materials only based on the positive comments of others. Instead, a careful review of the results of the program for significant positive effects for treatment compared to control classrooms would give teachers and university faculty more research-based reasons to assume the intended intervention will likely cause the expected positive results for student learning.

This study begins to address the need for professional development schools to demonstrate that the collaborative activity of schools and universities does produce significant positive changes in student learning. If national standards are a vehicle for improvement of the quality of education in our nation, perhaps professional development schools can play a role in introducing these standards within their network schools. Coupling implementation of these standards with a carefully designed action research model may be a powerful approach to ensure that students maximize their learning of advanced content standards.

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TABLE 1

Comparison of Fall 1995 and Spring 1996 Problem Solving Holistic Test Scores for Grade 4 Treatment Classrooms

Problem Solving Strategy by Grade	n	Mean Fall '95 (SD)	Mean Spring '96 (SD)	*t*	*p*
Organized List					
Grade 4 (A)	24	1.75 (.85)	3.67 (.70)	-8.54	.000***
Grade 4 (B)	22	2.27 (1.08)	3.45 (.86)	-4.03	.000***
Make a Table					
Grade 4 (A)	24	1.67 (.92)	3.71 (.62)	-9.02	.000***
Grade 4 (B)	22	1.82 (1.01)	3.52 (.81)	-6.12	.000***
Make a Pattern					
Grade 4 (A)	24	1.50 (.78)	3.33 (.82)	-7.95	.000***
Grade 4 (B)	22	1.73 (.88)	3.23 (1.02)	-5.21	.000***
Guess & Check					
Grade 4 (A)	24	1.13 (.34)	2.83 (.92)	-8.57	.000***
Grade 4 (B)	22	1.27 (.46)	3.29 (1.01)	-8.38	.000***
Make a Picture					
Grade 4 (A)	24	1.79 (.88)	3.13 (.85)	-5.33	.000***
Grade 4 (B)	22	1.82 (.96)	3.36 (.85)	-5.67	.000***

Problem Solving Strategy by Grade	N	Mean Fall '95 (SD)	Mean Spring '96 (SD)	*t*	*p*
Work Backwards					
Grade 4 (A)	24	1.71 (.96)	3.25 (1.07)	-5.26	.000***
Grade 4 (B)	22	1.36 (.66)	3.00 (1.26)	-5.28	.000***
Logical Reasoning					
Grade 4 (A)	24	1.29 (.62)	3.04 (1.00)	-7.28	.000***
Grade 4 (B)	22[1]				

***p ≤ .001
1--Post-test not administered

TABLE 2

Pre-Post Holistic Test Means (N=47) for Grade 4 Selected Problems After Teaching

Problem Solving Strategy	Mean After Teaching
Make a Picture	3.11
Make a Pattern	3.01
Make an Organized List	2.94
Use Logical Reasoning	3.50
Make a Table	3.26

TABLE 3

Pre-Post Holistic Test Mean Change Scores for High (N=4), Medium (N=4) and Low (N=4) Achievement Students in Grades 3 and 4

Achievement Level	Pre-Post Change Range	Mean Pre-Post Change
Highs	1.33-2.33	1.69
Mediums	1.00-2.17	1.54
Lows	1.50-2.50	1.74

TABLE 4

Holistic Test Score Means for High, Medium, and Low Achievement Students on Selected Problems in Grades 3 and 4

Problem Solving Strategy	n	Highs	Mediums	Lows
Make a Picture	4	3.75	3.75	2.00
Make a Pattern	4	3.25	2.00	2.00
Make an Organized List	2	4.00	3.50	2.50
Use Logical Reasoning	2	4.00	4.00	3.00
Make a Table	6	3.50	3.00	2.33
Work Backwards	2	3.00	1.00	1.00

TABLE 5

High (N=4), Medium (N=4), and Low (N=4) Achievement Students' Self-Perceptions of Their Ability to Solve Mathematical Problems on a 4-Point Scale for Grades 3 and 4

Achievement Level	Mean
Highs	3.25
Mediums	3.72
Lows	2.56

TABLE 6

Comparison of 1995 and 1996 Stanford Achievement Test Raw Scores (Mathematics Applications) for Treatment (T) and Matched Pairs Control (C) Classrooms

Grade	n	Mean 1995 (SD)	Mean 1996 (SD)	*F*	*p*
T Grade 4 (A)	19	29.95 (7.33)	30.83 (8.24)	0.12	.731
C Grade 4 (A)	19	29.95 (7.29)	33.27 (6.96)	1.99	.167
T Grade 4 (B)	18	28.00 (7.23)	31.78 (6.93)	2.56	.119
C Grade 4 (B)	18	28.00 (7.23)	30.22 (6.50)	.94	.339
T Grade 3	20	22.15 (1.66)	26.05 (6.04)	5.23	.028*
C Grade 3	20	22.15 (4.66)	24.75 (8.28)	1.50	.228

*$p \leq .05$

TABLE 7

Comparison of 1996 Connecticut Mastery Test Raw Scores for Treatment (N=19) and Matched Pairs Control (N=18) Grade 3 Classrooms

CMT Categories	Mean Treatment Grade 3 (SD)	Mean Control Grade 3 (SD)	*F*	*p*
Concepts	14.74 (4.57)	16.78 (3.53)	2.30	.139
Number Facts/ Computation	14.37 (1.17)	14.72 (1.57)	0.61	.439
Problem Solving	47.90 (7.37)	50.50 (9.11)	0.92	.345
Measurement/ Geometry	18.37 (2.69)	20.11 (3.22)	3.21	.082
Total	95.37 (13.66)	102.11 (15.84)	1.93	.174

TABLE 8
Comparison of Seven Problem Solving Objectives from the 1996 Connecticut Mastery Test for Treatment (N=19) and Matched Pairs Control (N=18) Grade 3 Classrooms

Problem Solving Objective	Mean Treatment Grade 3 (SD)	Mean Control Grade 3 (SD)	*F*	*p*
Solve problem: place value concepts	3.26 (.87)	3.28 (1.18)	.00	.966
Draw conclusions from graph/table/ chart	3.21 (1.08)	3.22 (1.52)	.00	.979
Write story problems from number sentences	3.53 (1.02)	2.83 (1.72)	2.24	.143
Identify operation to solve story problem	3.37 (1.12)	3.33 (1.14)	.01	.925
Solve story problems involving add/sub	3.42 (1.08)	3.28 (1.09)	.18	.671
Solve story problems with extraneous information	2.79 (1.08)	2.83 (1.10)	.01	.903
Identify needed information in problem situations	3.00	3.00	.00	1.000

TABLE 9

Comparison of 1995 and 1996 Connecticut Mastery Proportion Correct Test Scores for Grade 4 Treatment Classrooms

CMT Categories by Grade	n '95	n '96	Mean '95 (SD)	Mean '96 (SD)	*t*	*p*
Concepts						
Grade 4 (A)	19	16	.91 (.11)	.74 (.20)	3.04	.006**
Grade 4 (B)	18	15	.83 (.18)	.73 (.16)	1.66	.110
Number Facts/Computation						
Grade 4 (A)	19	16	.94 (.07)	.79 (.20)	2.87	.010**
Grade 4 (B)	18	15	.94 (.08)	.73 (.17)	4.38	.000***
Problem Solving						
Grade 4 (A)	19	16	.88 (.14)	.81 (.18)	1.19	.240
Grade 4 (B)	18	15	.90 (.09)	.85 (.13)	1.30	.210
Measurement/Geometry						
Grade 4 (A)	19	16	.88 (.10)	.78 (.18)	2.04	.054*
Grade 4 (B)	18	15	.86 (.10)	.74 (.08)	3.88	.001***
Total						
Grade 4 (A)	19	16	.89 (.11)	.79 (.18)	2.07	.049*
Grade 4 (B)	18	15	.88 (.08)	.78 (.11)	2.94	.007**

*$p \leq .05$, **$p \leq .01$, ***$p \leq .001$

TABLE 10

Comparison of Seven Problem Solving Objectives from the 1995 and 1996 Connecticut Mastery Test Scores for Grade 4 Treatment Classrooms

Problem Solving Objective	Mean '95 (SD)	Mean '96 (SD)	*t*	*p*
Solve problem: place value concepts				
Grade 4 (A)	3.74 (.65)	3.63 (.50)	.57	.57
Grade 4 (B)	3.78 (.55)	3.53 (.52)	1.32	.20
Draw conclusions from graph/table/ chart				
Grade 4 (A)	3.78 (.54)	3.31 (1.01)	1.69	.11
Grade 4 (B)	3.44 (.78)	3.27 (.80)	.64	.53
Write story problems from number sentences				
Grade 4 (A)	3.21 (1.51)	1.69 (1.74)	2.74	.01**
Grade 4 (B)	3.83 (.51)	2.53 (1.60)	3.02	.008**
Identify operation to solve story problem[1]				
Grade 4 (A)	3.53 (.91)	3.31 (1.01)	.65	.52
Grade 4 (B)	3.67 (.77)	3.33 (.72)	1.28	.21

Problem Solving Objective	Mean '95 (SD)	Mean '96 (SD)	*t*	*p*
Solve story problems involving add/sub[2]				
Grade 4 (A)	3.47 (.70)	3.63 (.62)	-.68	.50
Grade 4 (B)	3.78 (.55)	3.67 (.62)	.54	.59
Solve story problems with extraneous information				
Grade 4 (A)	3.05 (1.18)	3.44 (.89)	-1.10	.28
Grade 4 (B)	3.17 (1.20)	3.33 (1.18)	-.40	.69
Identify needed information in problem situations				
Grade 4 (A)	3.21 (1.36)	3.25 (1.06)	-.10	.92
Grade 4 (B)	3.44 (.98)	3.27 (.80)	.57	.57

1 Identify appropriate # sentences to solve problems for 1996 test.
2 Solve story problems involving multiplication division for 1996 test.
**$p \leq .01$